(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 389 740 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.02.2004 Bulletin 2004/08

(51) Int Cl.7: G02F 1/1333

(21) Application number: 03076784.2

(22) Date of filing: 10.06.2003

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: 19.06.2002 US 174596

(71) Applicant: EASTMAN KODAK COMPANY
Rochester, New York 14650 (US)

(72) Inventors:
- Cok, Ronald Steven,
c/o Eastman Kodak Company
Rochester, New York 14650-2201 (US)
- Miller, Michael Eugene,
c/o Eastman Kodak Company
Rochester, New York 14650-2201 (US)

(74) Representative: Weber, Etienne Nicolas et al
Kodak Industrie,
Département Brevets,
CRT,
Zone Industrielle
71102 Chalon sur Saône Cedex (FR)

(54) A tiled electro-optic imaging device

(57) A tiled electro-optic imaging device (8) such as a display and an image sensor includes two or more tiles (10) each tile (10) having a two dimensional array of pixels (16) and at least one non-linear edge, the tiles (10) being aligned edge to edge such that pixels (16) from the tiles (10) are inter-digitated along the non-linear edge, whereby the visibility of the non-linear edge is reduced and the visual uniformity of the device is enhanced.

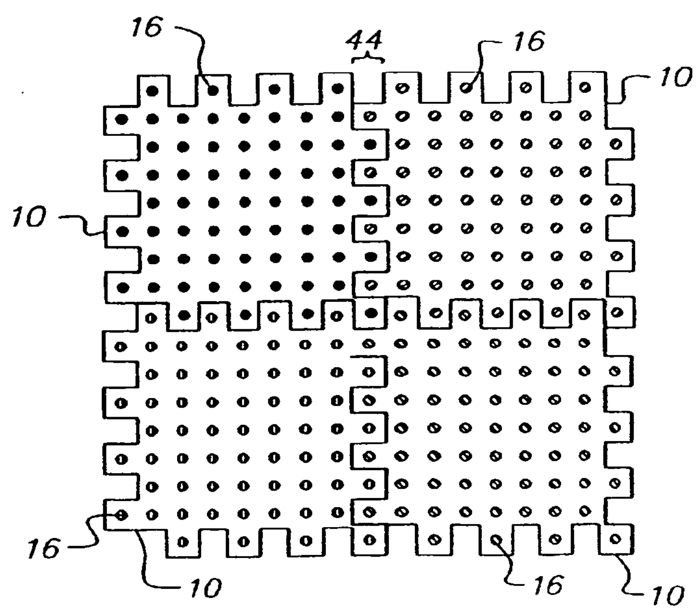

FIG. 3

EP 1 389 740 A1

Description

[0001] The present invention relates to tiled electro-optic imaging devices such as displays and image sensors and, more particularly, to improving the visual appearance of such devices.

[0002] It is known to increase the size of an electro-optic imaging device such as a flat panel display or an image sensor by forming the device using a plurality of tiles, each tile having a two dimensional array of pixels; see for example US 6,262,696 issued July 17, 2001 to Seraphim et al. Large tiled displays can also be made using an array of fiber optic panels in association with smaller displays. The fiber optic panels reduce the edge gap between the display tiles as described in US 4,299,447 issued November 10, 1981 to Soltan et al. WO 99/41732, Matthies et al., published August 19, 1999, describes forming a tiled display device from display tiles having pixel positions defined up to the edge of the tiles. One example of the use of tiles to increase the size of an image sensor is shown in US 5,572,034, issued November 5, 1996 to Karellas.

[0003] However, construction of tiled imaging devices is difficult. No two tiles, whether used alone or with fiber optic face plates, are precisely alike and the human eye is extremely sensitive to differences in color, brightness, and contrast in localized areas. There are calibration techniques by which the uniformity and color balance of a display or image sensor tile can be adjusted, but these are difficult, require re-adjustment over time, and are often inadequate. Moreover, the seams between the tile edges are very noticeable as the human eye is very sensitive to straight horizontal and vertical lines.

[0004] The assembly of flat-panel tiles is also a problem. In order to ameliorate the problems associated with tile seams, the tiled displays must be assembled very carefully and with great precision. This process is expensive and slow and products are prone to fall out of alignment over time without expensive forms or brackets to align the tiles once they are placed.

[0005] There is a need therefore for a tiled electro-optic imaging device that reduces the visibility of tile non-uniformities and tile seams, and that enhances the mechanical assembly of the tiles.

[0006] The need is met according to the present invention by providing a tiled electro-optic imaging device that includes two or more tiles, each tile having a two dimensional array of pixels and at least one non-linear edge, the tiles being aligned edge to edge such that pixels from the tiles are inter-digitated along the non-linear edge, whereby the visibility of the non-linear edge is reduced and the visual uniformity of the device is enhanced.

[0007] The present invention has the advantage that it decreases the visibility of tile seams, increases the apparent uniformity of the tiles, and facilitates the mechanical alignment of the tiles in the electro-optic imaging device.

Fig. 1 is a schematic diagram of a prior art tiled electro-optic imaging device;

Fig. 2 is a schematic diagram showing the outline of a tile of an electro-optic imaging device according to one embodiment of the present invention;

Fig. 3 is a schematic diagram of a tiled electro-optic imaging device according to one embodiment of the present invention;

Fig. 4 is a schematic diagram showing the outline of a tile of an electro-optic imaging device according to an alternative embodiment of the present invention;

Fig. 5 is a schematic diagram of a tiled electro-optic imaging device according to an alternative embodiment of the present invention;

Fig. 6 is a schematic diagram showing a tile edge according to a further embodiment of the present invention;

Fig. 7 is a schematic diagram showing a tile edge according to a still further embodiment of the present invention;

Fig. 8 is a schematic diagram showing a tile edge according to a still further embodiment of the present invention;

Fig. 9 is a schematic diagram illustrating the edge of a frame for holding tiles according to the present invention;

Fig. 10 is a schematic diagram showing tiles offset in a device according to the present invention;

Fig. 11 is a schematic diagram showing tiles rotated 45 degrees in a device according to the present invention;

Fig. 12 is a schematic diagram showing a plurality of tiles assembled on a board according to the present invention;

Fig. 13 is a schematic diagram of a device according to the present invention having tiles with image expanding fiber optic face plates;

Fig. 14 is a schematic diagram showing the outline of the fiber optic face plate shown in Fig. 13;

Fig. 15 is a schematic diagram showing a plurality of tiles in a display.

[0008] Referring to Fig. 1, a prior art tiled electro-optic imaging device (display or image sensor) **8** includes a two-by-two array of tiles **10**, having edges **14** and an array of pixels **16**. The edges **14** of the tiles **10** are aligned to produce a seam **12** between the edges of the tiles **14** and the last row or column of pixels **16** in the arrays. (The illustration of Fig. 1 is not drawn to scale to clarify the description). The edge seam **12** can be very visible to the human eye because it is straight, is horizontal or vertical, and has a direction that is the same as the pixel rows and columns. Moreover, small differences between the tiles, for example color, brightness, sensitivity or noise can be very visible to the human eye. According to the present invention, the perceived performance of the imaging device is improved by making

the tile edges non-linear such that pixels from adjacent tiles are inter-digitated along the non-linear edge, whereby the visibility of the non-linear edge is reduced and the visual uniformity of the device is enhanced. Moreover, the inter-digitation of the edges facilitates mechanical alignment of the tiles in the device.

[0009] Referring to Fig. 2, a tile having an edge structure according to one embodiment of the present invention is shown. In Fig. 2, the four edges of tile **10** are non-linear and the rows and columns of pixels **16** have a stepped pattern. Moreover, the pixel rows and columns on the opposing edges **24** and **26** of each tile have a complementary form such that the rows and columns on each tile edge can be inter-digitated as shown in Fig. 3. Referring to Fig. 3, four of the tiles **10** are arranged to form a regular array of pixels **16** with the result that pixels at the edges of the tiles are inter-digitated. This inter-digitation of the pixels at the tile edges has multiple benefits. First, the tile seam is less visible to the human eye because it is not straight, thus reducing the visibility of tile seams. Second, the inter-digitation of pixels from two adjacent tiles obscures differences in uniformity between the tiles. Third, the edges of the tiles can no longer slip with respect to each other because the stepped shape of the edge locks the tiles in position with respect to each other. Moreover, the tiles are easier to assemble into a device since they lock into a specific location with respect to each other.

[0010] Fig. 4 shows an alternative configuration of a tile capable of inter-digitiated pixels, with the advantage that the edge tab at one corner is connected by more material.

[0011] Applicants have conducted tests with human subjects simulating a tiled display device according to the present invention, on a CRT display that have shown that an inter-digitated edge between tiles increases by as much as fifty percent the threshold at which a global uniformity difference between the tiles is perceptible and reduces the visibility of an edge seam by as much as 50%.

[0012] Each tile in a multi-tile device according to the present invention has a complementary pattern on opposite edges **24** and **26** so that the tiles can be placed together with inter-digitated pixels along the edges. Tiles on the edges of a multi-tile device will not have a straight edge and pixels will be missing on the edge rows or columns. The edges can be masked with a frame to obscure the non-linear external edges. Alternatively, special edge and comer tiles may be created with one or more conventional straight edges.

[0013] The pixel control mechanisms for the tiles need not be modified and the row and column controls normally present in a device may operate normally, although pixels will be missing. In a display device, each tile's information overlaps with the neighboring tiles so that neighboring tiles will have edge rows and edge columns of information in common. Referring to Fig. 3, adjacent tiles overlap by one column or row of pixels **44**. This reduces the total number of rows and columns in the entire display by the total overlap amount.

[0014] A variety of tile edge shapes may be used. Deeper stair steps that are multiple pixels deep may be used, as shown in Fig. 5. Referring to Fig. 5, the tiles incorporate a stair-step edge that overlaps by two columns or rows of pixels **44**. The process may be extended to larger overlaps with improved seam-hiding and apparent tile uniformity but at the cost of more overlapped rows or columns.

[0015] Alternative edge shapes can be employed with the same edge pixel arrangements. For example, Figs. 6 and 7 illustrate tile edges that are triangular and sinusoidal, respectively. All of these physical shapes and others can accommodate a stair step pixel arrangement. The period of the inter-digitation can also be greater than one row or column of pixels as shown in Fig. 8.

[0016] The non-linear edge shape can be complemented at the edge of the display in a frame **52** designed to hold the array of tiles, as illustrated in Fig. 9.

[0017] Referring to Fig. 10, the tiles in the device having nonlinear edges according to the present invention can be offset from each to further obscure the tile seams. Referring to Fig. 11, the tiles can also be tilted such that the edges are not horizontal or vertical to further obscure the seams. For example the tiles can be tilted to 45 degrees as shown in Fig. 10.

[0018] Referring to Fig. 12, the tiles **10** include plugs **100** on their back sides that are electrically connected to conductors (not shown) on the tiles for addressing the pixels. The tiles **10** are mounted adjacent to each other on a circuit board **102** having an array of sockets **104** for removably receiving the plugs **100**. Alternatively, the tiles **10** can be surface mounted on the circuit board **102** using known surface mounting techniques.

[0019] In the embodiments discussed above, the tiles **10** included a substrate on which the pixels 16 were formed, and the edges of the substrates were non-linear and inter-digitated in the assembled device. Alternatively, the tiles **10** can be constructed conventionally with straight sides, and the pixels at the edges of the tiles can be inter-digitated using an image expanding fiber optic face plate. Fig. 13 shows a side view of the tile **10** having a substrate **60** and a fiber optic face plate **62**. The fiber optic face plate includes a plurality of optical fibers (or light pipes) **64** (one or more per pixel **66**). The fiber optic face plate **62** expands the apparent x and y dimensions of the underlying substrate as viewed from the side of the face plate farthest from the substrate. The tiles having fiber optic face plates are arranged side by side so that the outside edges of the face plates are immediately adjacent each other, leaving space between the underlying substrates to accommodate mounting and electronics.

[0020] In one embodiment, as shown in Fig. 13, the fibers **64** are of uniform diameter, and the area between the fibers is filled with an opaque filler, such as black

epoxy. One method for constructing such a fiber optic face plate is to hold both ends of the fibers in a fixture that determines their final location and potting them in place with the epoxy. Alternatively, the fibers can be tapered, with their narrow ends adjacent the pixels and the wide ends at the outside surface of the fiber optic face plate.

[0021] Fig. 14 is a schematic diagram illustrating the outline of the substrate **60** and the outline of the fiber optic face plate **62** as seen from above, showing the non-linear edges of the fiber optic plate and the underlying straight edged substrate (shown by dotted lines). The apparent locations of the underlying edge pixels at the top surface of the image expanding fiber optic face plate are shown by circles with lines coming from the underlying locations of the pixels on the substrate shown by circles with dotted lines. The edge pixels marked with x's are not used. The device is operated by ignoring the pixels with x's. In the case of a display, the unused pixels can be driven, or not. In the case of an image sensor, the signals from the unused pixels at the edges are ignored. In driving the tiled display having the image expanding fiber optic face plate, the image signals applied to the tiles **10** are treated as if the tiles overlap by one or more pixels along adjoining edges.

[0022] Referring to Fig. 15, electrical connection to the tiles is provided by multiple conductors **70** on the back sides of the tiles **10**, and the individual tiles **10** are mounted on a circuit board **72**. The circuit board **72** may include interface circuits **74** and connectors **76** for electrical connection between the tiles and the interface circuits. In a preferred embodiment, the device is an OLED display device, each tile having an encapsulating cover over the back side of the substrate, and the multiple conductors **70** may comprise a flex cable attached to the substrate **60** and the encapsulating cover is attached to the circuit board **72**.

Claims

1. A tiled electro-optic imaging device, comprising: two or more tiles each tile having a two dimensional array of pixels and at least one non-linear edge, the tiles being aligned edge to edge such that pixels from the tiles are inter-digitated along the non-linear edge, whereby the visibility of the non-linear edge is reduced and the visual uniformity of the device is enhanced.

2. A method of making a tiled electro-optic imaging device, comprising the steps of: providing a plurality of tiles, each tile having a two dimensional array of pixels and at least one non-linear edge, and arranging the tiles edge to edge such that pixels from the tiles are inter-digitated along the non-linear edge, whereby the visibility of the non-linear edge is reduced and the visual uniformity of the device is enhanced.

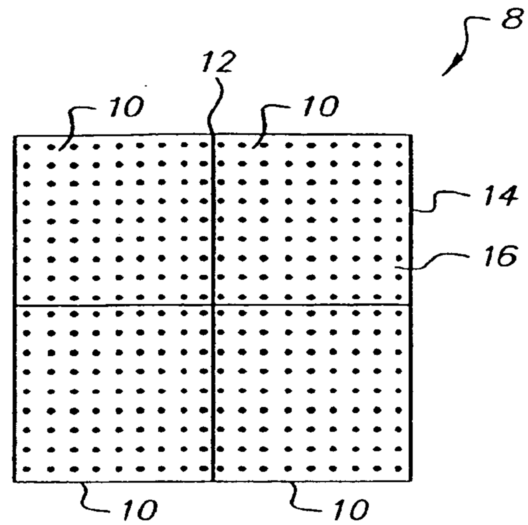

FIG. 1
(PRIOR ART)

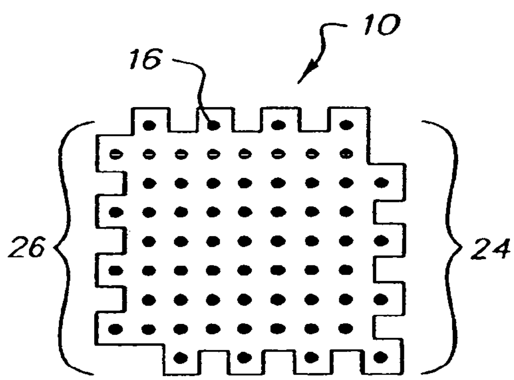

FIG. 2

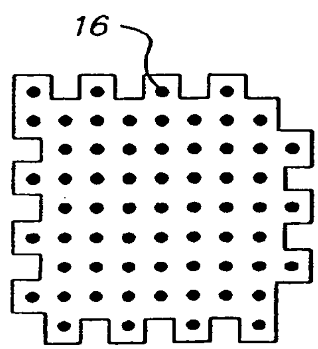

FIG. 4

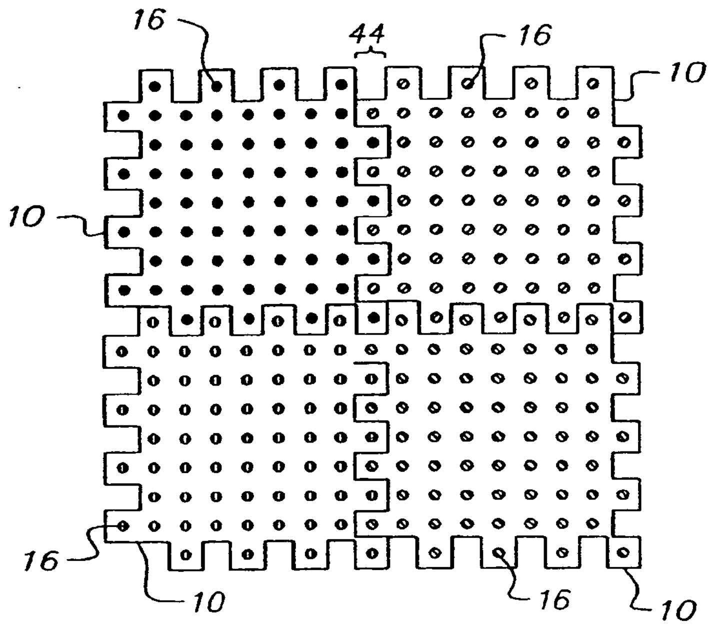

FIG. 3

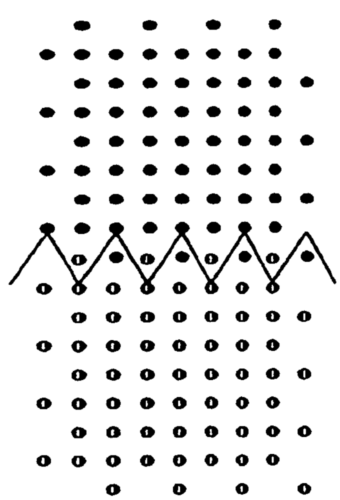

FIG. 6

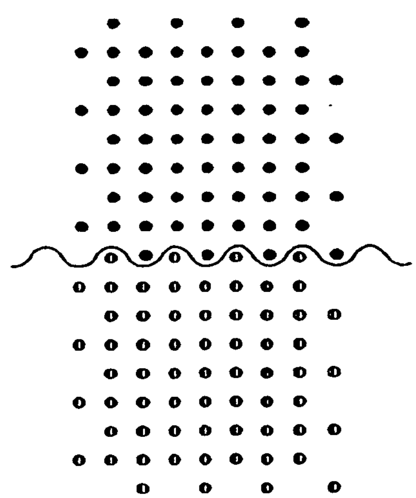

FIG. 7

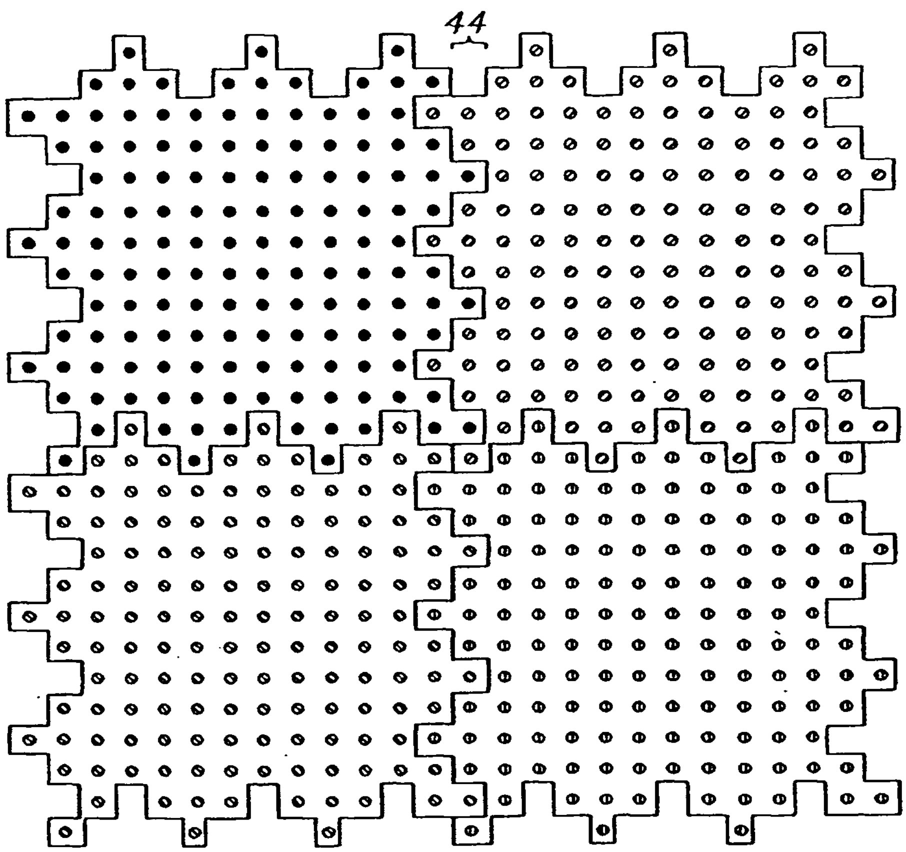

FIG. 5

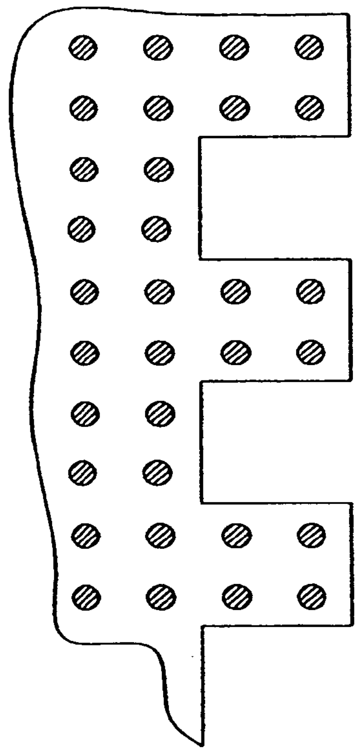

FIG. 8

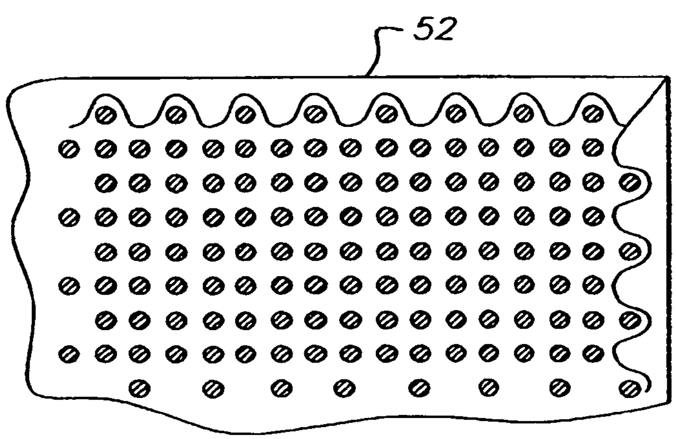

FIG. 9

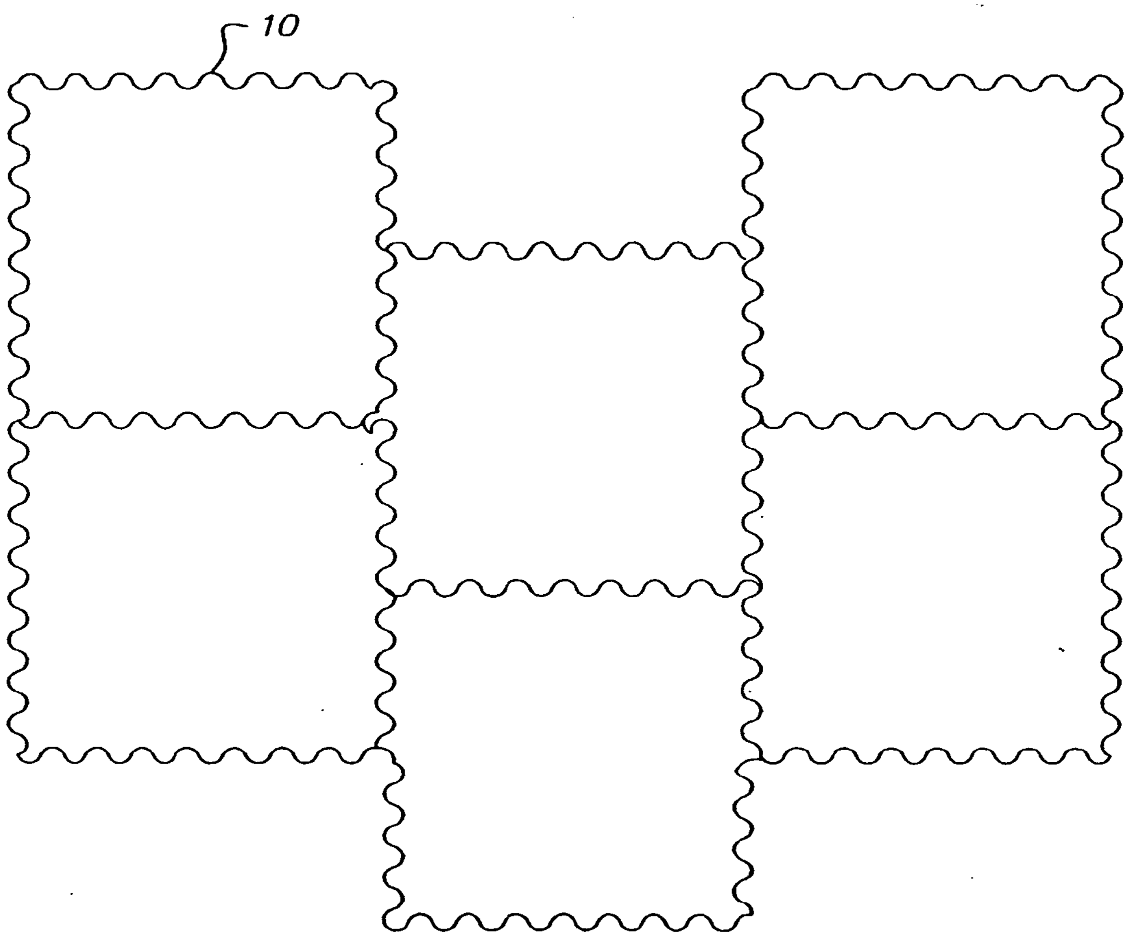

FIG. 10

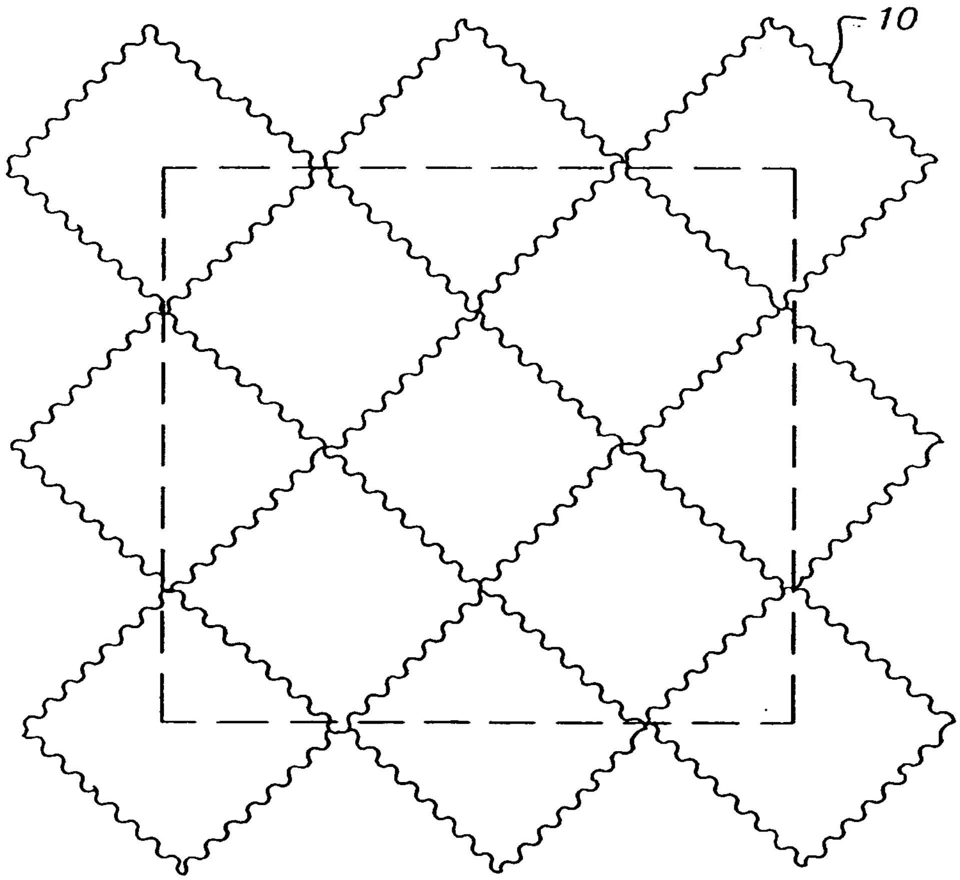

FIG. 11

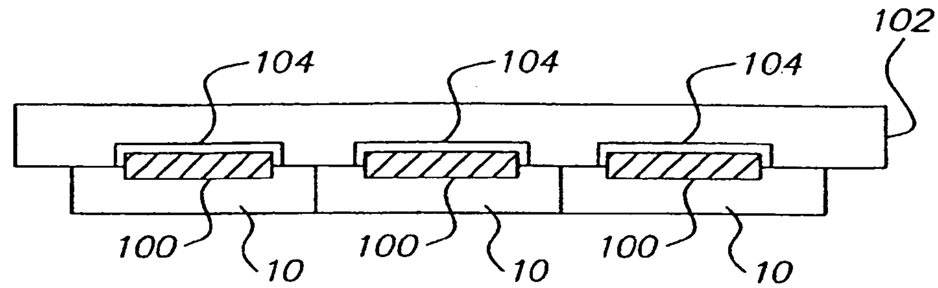

FIG. 12

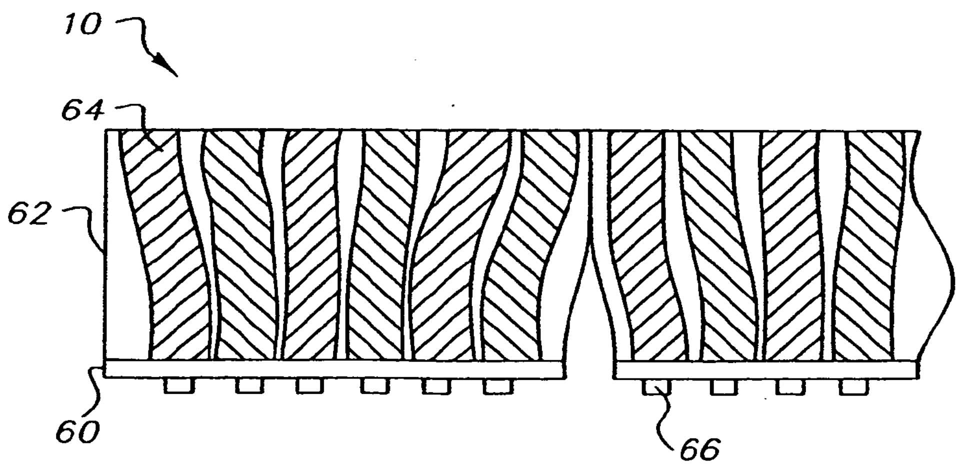

FIG. 13

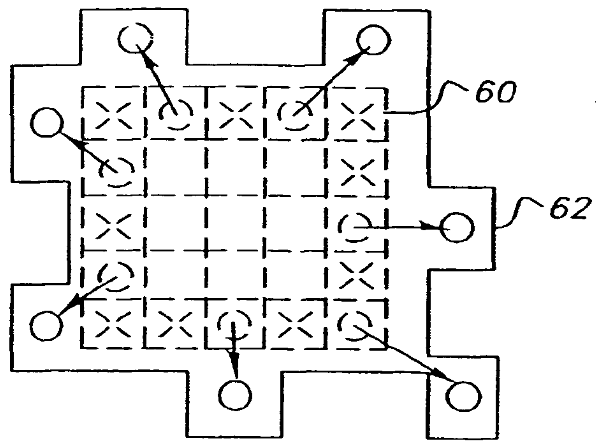

FIG. 14

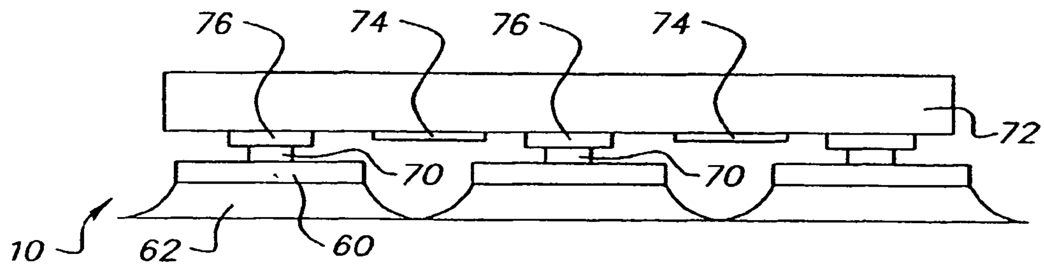

FIG. 15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 07 6784

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	US 2002/018151 A1 (KOBAYASHI TETSUYA ET AL) 14 February 2002 (2002-02-14) * figures 25-30,37,87-91 *	1,2 1,2	G02F1/1333
X Y	PATENT ABSTRACTS OF JAPAN vol. 012, no. 401 (P-776), 25 October 1988 (1988-10-25) -& JP 63 142330 A (ALPS ELECTRIC CO LTD), 14 June 1988 (1988-06-14) * abstract; figures 1,5 *	1,2 1,2	
Y	US 5 903 328 A (SKINNER DEAN W ET AL) 11 May 1999 (1999-05-11) * figure 1 *	1,2	
Y	US 6 370 019 B1 (ATHERTON JAMES HAROLD ET AL) 9 April 2002 (2002-04-09) * column 1 - column 2; figures 1,5 *	1,2	
A	EP 0 491 662 A (OPTICAL IMAGING SYST) 24 June 1992 (1992-06-24) * figures 4-6 *	1,2	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A,D	US 6 262 696 B1 (SERAPHIM DONALD P ET AL) 17 July 2001 (2001-07-17) * the whole document *	1,2	G02F H04N G02B
A	US 5 801 797 A (FUKUDA YUMI ET AL) 1 September 1998 (1998-09-01) * abstract; figure 1 *	1,2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	2 October 2003	Wolfrum, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 07 6784

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-10-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002018151 A1	14-02-2002	JP 11202793 A	30-07-1999
		US 2003098933 A1	29-05-2003
JP 63142330 A	14-06-1988	NONE	
US 5903328 A	11-05-1999	NONE	
US 6370019 B1	09-04-2002	AU 757997 B2	13-03-2003
		AU 2769599 A	30-08-1999
		CN 1291351 T	11-04-2001
		EP 1057216 A1	06-12-2000
		JP 2002503836 T	05-02-2002
		WO 9941787 A1	19-08-1999
		AU 748146 B2	30-05-2002
		AU 2769099 A	30-08-1999
		AU 3296999 A	30-08-1999
		CN 1291353 T	11-04-2001
		CN 1291354 T	11-04-2001
		EP 1057219 A1	06-12-2000
		EP 1057220 A2	06-12-2000
		JP 2002503832 T	05-02-2002
		WO 9941732 A2	19-08-1999
		WO 9941788 A1	19-08-1999
		US 2002050958 A1	02-05-2002
EP 0491662 A	24-06-1992	AT 138207 T	15-06-1996
		DE 69119569 D1	20-06-1996
		EP 0491662 A2	24-06-1992
US 6262696 B1	17-07-2001	US 5889568 A	30-03-1999
US 5801797 A	01-09-1998	JP 9311344 A	02-12-1997
		KR 262920 B1	01-08-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82